

Claims:

1. A method for improving the uniformity of a wet coating on a substrate comprising contacting and re-contacting the coating with wetted surface portions of a sufficient number of periodic pick-and-place devices having the same or substantially the same periods of contact with the substrate so that coating caliper defects ranging from a complete absence of coating to an excess of as much as 200% of the average coating caliper are converted to range from 85% to 115% of the average coating caliper.
2. A method according to claim 1 wherein all the pick-and-place devices have the same period of contact.
3. A method according to claim 1 wherein all the pick-and-place devices have substantially the same periods of contact and enable a reduction in the magnitude of repeating coating caliper surges, depressions or voids.
4. A method according to claim 3 wherein the device periods are within $\pm 0.05\%$ of one another.
5. A method according to claim 3 wherein the device periods are within $\pm 0.5\%$ of one another.
6. A method according to claim 3 wherein the device periods are within $\pm 1\%$ of one another.
7. A method according to claim 1 further comprising at least one pick-and-place device having a period of contact that differs by more than 1% from the average period of contact of the other devices.
8. A method according to claim 1 further comprising at least one pick-and-place device having a period of contact that differs by more than 5% from the average period of contact of the other devices.
9. A method according to claim 1 wherein coating voids are converted to be at least 90% of the average coating caliper.

10. A method according to claim 1 wherein coating excesses of up to 200% of the average coating caliper are converted to be no more than 110% of the average coating caliper.
- 5 11. A method according to claim 1 wherein the wet coating has a caliper variation, and wherein the period of the caliper variation, the size of the caliper variation or the period of contact of at least one device is changed to reduce or minimize coating defects.
- 10 12. A method according to claim 11 wherein the coating is applied to the substrate as a pattern of stripes interspersed with depressions and the pick-and-place devices comprise rolls.
13. A method according to claim 12 wherein the depressions comprise voids.
14. A method according to claim 12 wherein the coating is applied atop a previously applied wet coating.
- 15 15. A method according to claim 1 wherein the coating is converted to a void-free or substantially void-free coating having a thickness less than 5 micrometers.
16. A method according to claim 1 wherein the coating is converted to a void-free or substantially void-free coating having a thickness less than 0.5 micrometers.
- 20 17. A method for improving the uniformity of a wet coating on a substrate comprising contacting and re-contacting the coating with wetted surface portions of at least five periodic pick-and-place devices having the same or substantially the same periods of contact with the substrate.
18. A method according to claim 17 wherein all the pick-and-place devices have the same period of contact.
- 25 19. A method according to claim 17 wherein all the pick-and-place devices have substantially the same periods of contact and enable a reduction in the magnitude of repeating coating caliper surges, depressions or voids.

20. A method according to claim 19 wherein the device periods are within $\pm 0.05\%$ of one another.
21. A method according to claim 19 wherein the device periods are within $\pm 1\%$ of one another.
- 5 22. A method according to claim 17 further comprising at least one additional pick-and-place device having a period of contact that differs by more than 1% from the average period of contact of the other devices.
- 10 23. A method according to claim 17 further comprising at least one additional pick-and-place device having a period of contact that differs by more than 5% from the average period of contact of the other devices.
24. A method according to claim 17 wherein the pick-and-place devices comprise at least 10 rolls.
25. A method according to claim 17 wherein the pick-and-place devices comprise at least 20 rolls.
- 15 26. A method for coating a moving web comprising applying thereon a wet coating having a caliper variation; contacting and re-contacting the wet coating with wetted surface portions of one or more rolls having a period of contact with the web; and changing the period of the caliper variation, the size of the caliper variation or the period of contact of at least one roll to reduce or minimize coating defects.
- 20 27. A method according to claim 26 wherein the wet coating is applied as stripes separated by voids.
- 25 28. A method for coating a moving web comprising applying thereon a wet coating of stripes and contacting and re-contacting the wet coating with wetted surface portions of one or more rolls having a period of contact with the web, wherein the dimensionless stripe width and dimensionless roll size are within a white or light gray region depicted in **Fig. 14d** and its mirror image.

29. A method for coating a moving web comprising applying thereon a wet coating of stripes and contacting and re-contacting the coating with wetted surface portions of at least two rolls having the same or substantially the same period of contact with the web, wherein the dimensionless stripe width and dimensionless roll sizes are within a white or light gray region depicted in **Fig. 14f** and its mirror image.
30. A method for coating a moving web comprising applying thereon a wet coating of stripes and contacting and re-contacting the coating with wetted surface portions of at least three rolls having the same or substantially the same period of contact with the web, wherein the dimensionless stripe width and dimensionless roll sizes are within a white or light gray region depicted in **Fig. 14h** and its mirror image.
31. A method for coating a moving web comprising applying thereon a wet coating of stripes and contacting and re-contacting the coating with wetted surface portions of at least four rolls having the same or substantially the same period of contact with the web, wherein the dimensionless stripe width and dimensionless roll sizes are within a white or light gray region depicted in **Fig. 14j** and its mirror image.
32. An improvement station comprising a plurality of pick-and-place devices that can periodically contact and re-contact a wet coating at different positions on a substrate, wherein the coating has defects and an average coating caliper and wherein the number of pick-and-place devices having the same or substantially the same periods of contact with the substrate is sufficient so that coating caliper defects ranging from a complete absence of coating to an excess of as much as 200% of the average coating caliper are converted to range from 85% to 115% of the average coating caliper.
33. An improvement station according to claim 32 wherein all the pick-and-place devices have the same period of contact.

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34. An improvement station according to claim 32 wherein all the pick-and-place devices have substantially the same periods of contact and enable a reduction in the magnitude of repeating coating caliper surges, depressions or voids.
- 5 35. An improvement station according to claim 34 wherein the device periods are within $\pm 0.05\%$ of one another.
36. An improvement station according to claim 34 wherein the device periods are within $\pm 0.5\%$ of one another.
37. An improvement station according to claim 34 wherein the device periods are within $\pm 1\%$ of one another.
- 10 38. An improvement station according to claim 34 further comprising at least one pick-and-place device having a period of contact that differs by more than 1% from the average period of contact of the other devices.
- 15 39. An improvement station according to claim 32 wherein the period of contact of one or more of the devices can be changed to reduce or minimize coating defects.
40. An improvement station according to claim 32 wherein the pick-and-place devices comprise rolls.
41. An improvement station comprising at least five pick-and-place devices that can periodically contact and re-contact a wet coating at different positions on a substrate and have the same or substantially the same periods of contact with the substrate.
- 20 42. An improvement station according to claim 41 wherein all the pick-and-place devices have the same period of contact.
- 25 43. An improvement station according to claim 41 wherein all the pick-and-place devices have substantially the same period of contact and enable a reduction in the magnitude of repeating coating caliper surges, depressions or voids.

44. An improvement station according to claim 43 wherein the device periods are within $\pm 0.05\%$ of one another.
45. An improvement station according to claim 43 wherein the device periods are within $\pm 0.5\%$ of one another.
- 5 46. An improvement station according to claim 43 wherein the device periods are within $\pm 1\%$ of one another.
47. An improvement station according to claim 41 further comprising at least one additional pick-and-place device having a period of contact that differs by more than 1% from the average period of contact of the other devices.
- 10 48. An improvement station according to claim 41 further comprising at least one additional pick-and-place device having a period of contact that differs by more than 5% from the average period of contact of the other devices.
49. An improvement station according to claim 41 wherein the pick-and-place devices comprise at least 10 rolls.
- 15 50. An improvement station according to claim 41 wherein the pick-and-place devices comprise at least 20 rolls.
51. An improvement station according to claim 41 wherein the pick-and-place devices comprise at least 50 rolls.
- 20 52. A coating apparatus comprising a coating station that applies an uneven coating to a substrate and an improvement station comprising a plurality of pick-and-place devices that can periodically contact and re-contact the applied coating at different positions on the substrate, wherein the number of pick-and-place devices having the same or substantially the same period of contact with the substrate is sufficient so that coating caliper defects ranging from a
- 25 complete absence of coating to an excess of as much as 200% of the average coating caliper are converted to range from 85% to 115% of the average coating caliper.

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53. A coating apparatus according to claim 52 wherein all the pick-and-place devices have the same period of contact.
54. A coating apparatus according to claim 52 wherein all the pick-and-place devices have substantially the same periods of contact and enable a reduction in the magnitude of repeating coating caliper surges, depressions or voids.
55. A coating apparatus according to claim 54 wherein the device periods are within $\pm 0.05\%$ of one another.
56. A coating apparatus according to claim 54 wherein the device periods are within $\pm 0.5\%$ of one another.
- 10 57. A coating apparatus according to claim 54 wherein the device periods are within $\pm 1\%$ of one another.
58. A coating apparatus according to claim 52 further comprising at least one additional pick-and-place device having a period of contact that differs by more than 1% from the average period of contact of the other devices.
- 15 59. A coating apparatus according to claim 52 further comprising at least one additional pick-and-place device having a period of contact that differs by more than 5% from the average period of contact of the other devices.
60. A coating apparatus according to claim 52 wherein the period of contact of one or more of the devices can be changed to reduce or minimize coating defects.
- 20 61. A coating apparatus according to claim 52 wherein the pick-and-place devices comprise rolls.
62. A coating apparatus according to claim 52 wherein the coating station applies a discontinuous coating.
- 25 63. A coating apparatus according to claim 62 wherein the coating station applies the coating as a pattern of stripes.

64. A coating apparatus according to claim 63 wherein there are at least two rolls and the dimensionless stripe width and dimensionless roll sizes are within a white or light gray region depicted in **Fig. 14f** and its mirror image.
- 5 65. A coating apparatus according to claim 63 wherein there are at least three rolls and the dimensionless stripe width and dimensionless roll sizes are within a white or light gray region depicted in **Fig. 14h** and its mirror image.
66. A coating apparatus according to claim 63 wherein there are at least four rolls and the dimensionless stripe width and dimensionless roll sizes are within a white or light gray region depicted in **Fig. 14j** and its mirror image.
- 10 67. A coating apparatus according to claim 52 further comprising a transfer station for transferring the coating from the substrate to a second substrate.
68. A coating apparatus according to claim 67 wherein the transfer station comprises a belt and the coating station applies a pattern of stripes to a wet region of the belt without a three phase wetting line at the stripe application region.
- 15 69. A coating apparatus according to claim 52 wherein one or more sensors or controls alter the period of one or more of the pick-and-place devices during operation of the apparatus.
70. A coating apparatus according to claim 52 wherein the coating is applied as a non-uniform coating of drops.
- 20 71. A coating apparatus according to claim 52 wherein the coating is applied as a discontinuous coating of drops.
72. A coating apparatus according to claim 52 further comprising a drying station.
73. A coating apparatus according to claim 72 wherein at least part of the improvement station extends into the drying station.
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74. A coating apparatus according to claim 52 wherein the uneven coating has a periodic caliper variation and wherein the period of the caliper variation, the size of the caliper variation or the period of contact of one or more of the devices is changeable to reduce or minimize coating defects.
- 5 75. A coating apparatus comprising a coating station that applies an uneven coating to a substrate and an improvement station comprising at least five pick-and-place devices that can periodically contact and re-contact the applied coating at different positions on the substrate and have the same or substantially the same periods of contact with the substrate.
- 10 76. A coating apparatus according to claim 75 wherein all the pick-and-place devices have the same period of contact.
77. A coating apparatus according to claim 75 wherein all the pick-and-place devices have substantially the same period of contact and enable a reduction in the magnitude of repeating coating caliper surges, depressions or voids.
- 15 78. A coating apparatus according to claim 77 wherein the device periods are within $\pm 0.05\%$ of one another.
79. A coating apparatus according to claim 77 wherein the device periods are within $\pm 0.5\%$ of one another.
80. A coating apparatus according to claim 77 wherein the device periods are within $\pm 1\%$ of one another.
- 20 81. A coating apparatus according to claim 75 further comprising at least one additional pick-and-place device having a period of contact that differs by more than 1% from the average period of contact of the other devices.
82. A coating apparatus according to claim 75 further comprising at least one additional pick-and-place device having a period of contact that differs by more than 5% from the average period of contact of the other devices.
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83. A coating apparatus according to claim 75 wherein the pick-and-place devices comprise rolls.
84. A coating apparatus according to claim 83 comprising at least 10 rolls.
85. A coating apparatus according to claim 83 comprising at least 20 rolls.
- 5 86. A coating apparatus according to claim 83 comprising at least 50 rolls.
87. A coating apparatus according to claim 75 wherein the coating station applies a discontinuous coating.
88. A coating apparatus according to claim 87 wherein the coating station applies the coating as a pattern of stripes.
- 10 89. A coating apparatus according to claim 88 wherein the dimensionless stripe width and dimensionless roll sizes are within a white or light gray region depicted in **Fig. 14l** and its mirror image.
90. A coating apparatus according to claim 88 wherein there are at least ten rolls and the dimensionless stripe width and dimensionless roll sizes are within a white or light gray region depicted in **Fig. 14n** and its mirror image.
- 15 91. A coating apparatus according to claim 75 further comprising a transfer station for transferring the coating from the substrate to a second substrate.
92. A coating apparatus according to claim 91 wherein the transfer station comprises a belt and the coating station applies a pattern of stripes to a wet region of the belt without a three phase wetting line at the stripe application region.
- 20 93. A coating apparatus according to claim 75 wherein one or more sensors or controls alter the period of one or more of the pick-and-place devices during operation of the apparatus.

94. A coating apparatus according to claim 75 wherein the coating is applied as a non-uniform coating of drops.
95. A coating apparatus according to claim 75 wherein the coating is applied as a discontinuous coating of drops.
- 5 96. A coating apparatus according to claim 75 wherein the uneven coating has a periodic caliper variation and wherein the period of the caliper variation, the size of the caliper variation or the period of contact of one or more of the devices is changeable to reduce or minimize coating defects.
97. A coating apparatus according to claim 75 further comprising a drying station.
- 10 98. A coating apparatus according to claim 97 wherein at least part of the improvement station extends into the drying station.